PATENT COOPERATION TREATY

PCT

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

FENSTER, Paul
FENSTER & COMPANY,
INTELLECTUAL PROPERTY 2002 LTD.
P.O. Box 10256
Petach Tikva 49002
ISRAEL

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	12.11.2004
Applicant's or agent's file reference: 013/03675	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IL 03/00603	23.07.2003	25.07.2002

Applicant: NANOMOTION LTD. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the International preliminary examining authority:	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Commare, I Tel. +49 89 2399-2883

Form PCT/IPEA/416 (January 2004)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 013/03675	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/IL 03/00603	International filing date *(day/month/year)* 23.07.2003	Priority date *(day/month/year)* 25.07.2002
International Patent Classification (IPC) or both national classification and IPC H01L41/09		
Applicant NANOMOTION LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
25.02.2004	12.11.2004
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Meul, H Telephone No. +49 89 2399-2494

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL 03/00603

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-12 as originally filed

Claims, Numbers

1-24 received on 12.10.2004 with letter of 12.10.2004

Drawings, Sheets

1-6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-24
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-24
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-24
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

   D1: K. MORI et al.: "Ultrasonic linear motor for a high precision X-Y stage" IEEE 1989 ULTRASONICS SYMPOSIUM PROCEEDINGS, MONTREAL, pages 657-660;
   D2: EP 0 313 072 A (HITACHI LTD) 26 April 1989
   D3: EP 0 755 054 A (NANOMOTION LTD) 22 January 1997

2. The document D1 is regarded as being the closest prior art to the subject-matter of present claims 1 and 23 and shows (see Fig. 1 and the related text of D1) a vibrating-type driving unit comprising a pair of piezoelectric devices mounted on a base, a vibrator for transmitting the vibration of the piezoelectric devices, and a driving head disposed on a distal end of the vibrator and adapted to come into contact with the body to be moved. D1 further discloses a power supply selectively operated to drive the motor either in a coarse positioning mode or in a fine positioning mode. The coarse mode is a friction drive mechanism using ultrasonic vibration generated by a resonance high frequency AC voltage applied with phase difference to the two piezoelectric devices. The fine mode is a direct drive mechanism with a DC voltage applied to the two piezoelectric devices.

3. The subject-matter of claims 1 and 23 differs from this known motor or actuator in that a single piezoelectric vibrator rather than a pair of piezoelectric devices drives the coupling surface of the motor or actuator. The subject-matter of claims 1 and 23 is therefore new (Article 33 (2) PCT).

4. The problem to be solved by the present invention may be regarded as to simplify the structure of the vibration drive unit while maintaining the option of a DC mode operation.

   The solution to this problem proposed in claims 1 and 23 of the present application is considered as involving an inventive step (Article 33 (3) PCT) for the following reasons:

D1 and also the document D2 describing the same type of ultrasonic linear motor as D1 do not give any hint to a vibrator structure consisting of a single piezo-ceramic vibrator body. The document D3 teaches that a single piezoelectric vibrator can be used as a disc drive by selectively electrifying a plurality of electrodes attached to the piezoceramic vibrator body with a time varying voltage. The D3 apparatus can switch between a fast operating AC mode and a high resolution, low speed mode utilizing pulsed voltages. However, it appears not obvious to combine a document such as D1 or D2 which teaches that two piezoelectric vibrators are needed to provide a DC mode of operation with a document such as D3 which teaches a single piezoelectric vibrator excited by AC or pulsed voltages and which does not give any hint to a DC fine positioning mode.

5. Claims 2-22 and 24 are dependent on claims 1 and 23, respectively, and as such also meet the requirements of the PCT with respect to novelty and inventive step.

6. Observation on the clarity of claims 1 and 23:

6.1 The term "single piezoelectric vibrator" used in claims 1 and 23 is not clear (Article 6 PCT). A single piezoelectric vibrator is a single element made to vibrate due to the piezoelectric effect. It is not precluded that such element comprises a non-piezoelectric vibrator body coupled to one or more piezoelectric elements as known from D1 or D2. For the sake of clarity, the term "single piezoelectric vibrator" in claim 1 and 23 should have been replaced by a wording such as "single piezoelectric vibrator consisting of a piezoceramic body having a plurality of electrodes attached to its major surfaces and being coupled to a coupling surface which is pressed to a load".

6.2 The wording "power supply selectively operable" used in claim 1 is not clear (Article 6 PCT). For the sake of clarity, this wording should have been replaced by a formulation such as "power supply being controlled to select either a first or a second mode of operation, in the first mode at least one vibrator electrode being electrified with time varying voltage to generate ...., in the second mode at least one vibrator electrode being electrified with constant DC voltage to displace ... and move thereby the load to a desired position".

6.3 A lack of clarity arises in claim 24 because a non-collinearly displacable coupling

surface of the actuator according to claim 23 cannot be further specified by restricting its non-collinear mobility to a collinear one (Article 6 PCT).

013/03675 A02

CLAIMS

1. A piezoelectric motor for moving and positioning a load, the motor comprising:

a coupling surface which is pressed to a load;

a single piezoelectric vibrator coupled to the coupling surface and having a plurality of electrodes; and

a power supply selectively operable to electrify at least one vibrator electrode with time varying voltage to generate vibrations in the coupling surface that step the load to a desired position or to electrify at least one vibrator electrode with constant DC voltage to displace the coupling surface and maintain it displaced and move thereby the load to a desired position.

2. A piezoelectric motor according to claim 1 wherein displacements generated by DC voltage applied by the power supply are substantially collinear.

3. A piezoelectric motor according to claim 1 or claim 2 wherein the DC voltage is controllable to generate displacements that are not collinear.

4. A piezoelectric motor according to any of the preceding claims wherein the vibrator is formed in a shape of a rectangular plate having first and second parallel, relatively large face surfaces and long and narrow edge surfaces and wherein the plurality of electrodes comprises at least one electrode on each face surface.

5. A piezoelectric motor according to claim 4 wherein the at least one electrode on the first face surface comprises four quadrant electrodes each of which covers substantially all of a different quadrant of the face surface.

6. A piezoelectric motor according to claim 5 wherein the at least one electrode on the second face surface comprises a single electrode that covers substantially all the area of the second face surface.

7. A piezoelectric motor according to 6 wherein the single electrode is grounded.

8. A piezoelectric motor according to any of claims 4-7 wherein the coupling surface is a surface on a short edge surface of the vibrator.

9. A piezoelectric motor according to any of claims 4-8 wherein the power supply electrifies at least one quadrant electrode relative to the single electrode to bend the vibrator in its plane and displace thereby the coupling surface.

10. A piezoelectric motor according to any of claim 4-8 wherein the power supply electrifies quadrant electrodes along a same long edge surface with a DC voltage and quadrant electrodes along opposite long edges with opposite polarity voltage.

11. A piezoelectric motor according to any of claims 4-9 wherein the power supply electrifies quadrant electrodes along a same long edge surface with a DC voltage and quadrant electrodes along opposite long edges are floating.

12. A piezoelectric motor according to any of claims 4-11 wherein the power supply electrifies quadrant electrodes along a same diagonal with a same DC voltage and quadrant electrodes along different diagonals with opposite polarity voltage.

13. A piezoelectric motor according to any of claims 4-12 wherein the power supply electrifies quadrant electrodes along one diagonal of the first surface with a DC voltage and quadrant electrodes along the other diagonal are floating.

14. A piezoelectric motor according to any of claims 4-13 wherein the power supply electrifies quadrant electrodes along one diagonal of the first surface with a DC voltage and quadrant electrodes along the other diagonal are grounded.

15. A piezoelectric motor according to any of claims 1-3 wherein the vibrator is formed the shape of a rectangular parallelepiped constructed from a plurality of thin rectangular layers of piezoelectric material bonded together, each layer having relatively large face surfaces and long and short edge surfaces, and wherein the plurality of electrodes comprises at least one electrode substantially contiguous with each face surface of the layers.

013/03675 A02

16. A piezoelectric motor according to claim 15 wherein the coupling surface is located on a short edge of the vibrator.

17. A piezoelectric motor according to claim 16 wherein the power supply electrifies at least one configuration of electrodes with DC voltage to bend the vibrator in the plane of the face surfaces and displace thereby the coupling surface.

18. A piezoelectric motor according to claim 16 or claim 17 wherein the power supply electrifies at least one configuration of electrodes with DC voltage to bend the vibrator perpendicular to the plane of the face surfaces and displace thereby the coupling surface.

19. A piezoelectric motor according to any of the preceding claims wherein DC voltage is controlled to control magnitude of displacement of the coupling surface to resolution equal to or better than a 5 nanometers.

20. A piezoelectric motor according to any of the preceding claims wherein DC voltage is controlled to control magnitude of displacement of the coupling surface to resolution equal to or better than a 2 nanometers.

21. A piezoelectric motor according to any of the preceding claims wherein DC voltage is controlled to control magnitude of displacement of the coupling surface to resolution equal to or better than a 1 nanometer.

22. A piezoelectric motor according to any of the preceding claims wherein DC voltage is controlled to control magnitude of displacement of the coupling surface to resolution equal to or better than a 0.1 nanometer.

23. A piezoelectric actuator for moving and positioning a load, the actuator comprising:

a coupling surface which is pressed to a load to friction couple the coupling surface to the load;

a single piezoelectric vibrator coupled to the coupling surface and having a plurality of electrodes; and

a power supply operable to electrify at least one electrode of the plurality of electrodes with constant DC voltage to selectively displace the coupling surface along different non-collinear directions and maintain it displaced and drag thereby the load to a desired position.

24. A piezoelectric actuator according to claim 23 wherein displacements generated by the DC voltage applied by the power supply are substantially collinear.